NATURAL NETWORK SUBDIVISION

Alberta
MUNICIPAL AFFAIRS
Innovative Housing Grants Program

NATURAL NETWORK SUBDIVISION

February 1991

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in Association with

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FOREWORD

The project documented in this report received funding under the Innovative Housing Grants Program of Alberta Municipal Affairs. The Innovative Housing Grants Program is intended to encourage and assist housing research and development which will reduce housing costs, improve the quality and performance of dwelling units and subdivisions, or increase the long term viability and competitiveness of Alberta's housing industry.

The Program offers assistance to builders, developers, consulting firms, professionals, industry groups, building products manufacturers, municipal governments, educational institutions, non-profit groups and individuals. At this time, priority areas for investigation include building design, construction technology, energy conservation, site and subdivision design, site servicing technology, residential building product development or improvement and information technology.

As the type of project and level of resources vary from applicant to applicant, the resulting documents are also varied. Comments and suggestions on this report are welcome. Please send comments or requests for further information to:

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ACKNOWLEDGEMENTS

This study builds on the earlier research and planning that was undertaken by **Mr. Robert Corbett,** who assisted in this project and is co-author of this report.

We also wish to acknowledge the following individuals who have made important and valuable contributions to this study:

Jim Brown, Vice President; Lehndorff Land Development Inc.
Brian Middleton, Marketing Director; Lehndorff Land Development Inc.
Larry Newton, M.C.I.P.
Tom Baba, P. Eng.

As well, we would like to thank the following agencies who made suggestions with respect to possible modifications to current standards to enable a subdivision such as the Natural Network Subdivision to be developed in Edmonton.

<u>City of Edmonton</u>:

. Planning & Development:	Brant Mohr
. Environmental Services:	Clayton Tiedemann
	Justin Guanlao
. Transportation:	Peter Heppleston
	Ray Davis
. Edmonton Power:	Lance Barker
	Charlie Clarke
	Ted Chorley

<u>Northwestern Utilities Limited</u>:	Harold Ross

Without the assistance of the above noted agencies and individuals this study could not have reflected a practical situation for comparative purposes.

EXECUTIVE SUMMARY

There is ongoing interest among urban planners and related professionals in developing new designs for residential developments which will exhibit positive environmental strategies and cost-effective servicing strategies. The purpose of this project was to evaluate one such strategy - Natural Networking - as a land planning concept for use in Alberta. Under this planning approach, a hexagonal grid is used as a basis for the layout of roads and services.

The Natural Network Subdivision appears to offer both design and cost benefits. While natural networking has been developed on a small basis in the United States, no detailed theoretical analysis or large-scale applications of the concept have been undertaken. In particular, there have been no studies which tested the feasibility of the concept within Alberta's planning and legislative environment, or evaluated it relative to more traditional layouts in the context of prevailing market forces.

Although natural networking has only been applied on a limited basis to very small subdivisions, there is preliminary evidence to suggest that its application on a larger scale could result in the reduction of service lines and roadways by up to 20%, compared to traditional layouts. This would result in a substantial reduction in per lot costs, and contribute to lower housing costs overall.

Because of these potential cost-savings, this project, which investigates the planning and analysis of the Natural Network System (NNS), addressing specific planning items such as roadways, utilities, lot quality and the ability to accommodate conventional and non-conventional housing forms within an Alberta (Edmonton) legislative and market oriented development environment, was undertaken.

The study objectives were to:

1) investigate the concept of natural networking as an approach to residential land development

2) undertake both a general analysis of natural networking as applied to large scale area planning and a detailed analysis of the concept as applied to a small scale residential subdivison

3) analyze the adaptability of this form of subdivision to assess its ability to accommodate natural environmental occurrences that could potentially restrict development

4) assess the feasibility of applying the natural network concept in Alberta from a legislative and regulatory perspective.

The research for this planning approach included:

1) Consultation and Literature Review
   Extensive input was obtained from Robert Corbett, an architect/planner practising in Boston, Massachusetts, who pioneered this approach, and an extensive review of literature on natural networking and the theory behind it was carried out.

2) Experimentation & Design Application
   An overall plan was prepared for a large parcel of land (160 acres) and a detailed plan for a smaller (40 acres) parcel.

3) Cost Analysis
   A detailed costs analysis for each one of the infrastructure components was made on a comparative basis against a conventional subdivision and an analysis of potential resulting lot values was undertaken for each approach.

4) Discussion with the Regulatory Officials

This included interviewing individuals who may consider natural networking, and meeting with representatives of the City of Edmonton and utility companies to obtain their views of this planning concept.

The major findings of the study include:

-- a 13% reduction in infrastructure costs per lot with Natural Network Subdivision compared to the traditional subdivision,
-- the quality of these lots with regard to sight lines, access and perceived streetscape provides a living environment that is at least equal to current standards and suggests an overall increase of 15% in lot values,
-- some lots have more frontage than depth, and would require unique housing forms which have already been developed in the United States,
-- the system on a larger scale lends itself to multiple housing with potential unique applications to this approach,
-- confirmation that this subdivision could be developed in the City of Edmonton, because of its ability to accommodate various restrictions and still comply with overall requirements,
-- although the majority of servicing concerns were resolved, some specific issues such as utility access would have to be addressed but this was not considered an insurmountable barrier.

The results of this study indicate that the Natural Network Subdivision should be seriously considered for single family development in the Alberta market or any similar development environment. Further, there is strong evidence to suggest that NNS can readily accommodate the multi-family housing types which would be desired in an economically and socially mixed community.

Because the potential savings are based on reduced service runs and do not influence cultural or general planning theories, Natural Networking should be highly transferable, and could provide beneficial alternatives to conventional subdivision development.

1.0 INTRODUCTION

This chapter summarizes the study purpose, scope and focus, the problems to be addressed, and the report structure.

1.1 Purpose of the Study

The purpose of this project was to evaluate natural networking as a land planning concept for use in Alberta. Natural Networking uses a hexagonal grid as the basis for layout of roads and services.

This form of subdivision was developed on a small scale in the United States. It was pioneered by Robert Corbett, an architect/planner practising in Boston, Massachusetts. Mr. Corbett furthered his research while obtaining a Master of Design Studies at Harvard University, 1986-87 where he wrote a paper titled "The Theory and History of Urban Form". He was inspired by the polygon, a geometric shape found in great abundance in nature. Corbett observed that "in all creation nature is frugal and never builds with more when less will do. She creates an amazing diversity from a limited inventory of building blocks assembled in a few patterns."

Although natural networking has only been applied on a limited basis to one very small subdivision, there is preliminary evidence to suggest that its application on a larger scale in a single and multi-family subdivision could result in the reduction of service lines and roadways by up to 20%, compared to traditional layouts. Based on this possibility it was decided to pursue the planning and analysis of the natural networking system, addressing specific planning items such as roadways, utilities, lot quality and NNS's ability to accommodate conventional and non-conventional housing forms.

The detailed objectives were to:

- investigate the concept of natural networking as an approach to residential land development
- undertake both a general analysis of natural networking as applied to large scale area planning and a detailed analysis of the concept as applied to a small scale residential subdivision, with special consideration to project feasibility, quality and cost-effectiveness of the resulting residential environment,
- analyze the adaptability of this form of subdivision to allow for natural environmental occurrences, such as drainage courses, creeks, ravines and other factors that would pose potential restrictions on development,
- assess the feasibility of applying the natural networking concept in Alberta from a legislative and regulatory perspective, and identify those changes in planning law, planning theory or land development practices which would be required to adopt natural networking in Alberta.

1.2 Statement of the Problem

While natural networking has been developed on a limited basis in the United States, no detailed theoretical analyses or large-scale applications of the concept as it would apply to the largely single family environment generally found in Alberta subdivisions have been undertaken. In particular, there have been no studies which tested the feasibility of the concept within Alberta's planning and legislative environment, or evaluated the resulting lots and potential house plans relative to more traditional layouts in the context of prevailing market forces.

In recent years land and lot costs have been relatively stable in Alberta, but there is currently an increase occurring. If attractive lots can be placed on the market at a lesser cost, this would help

in the marketplace since purchasers are looking for quality housing at the best price. More economical housing would provide a viable alternative to land developers and potential purchasers. This study responds to that need.

1.3 Scope and Focus of the Study

The study encompassed the investigation, theoretical application and evaluation of the natural network planning concept in an Alberta context. The work included a general evaluation of the concept for a 64.7 hectare (160-acre) parcel of land being considered for development in the Edmonton area, and a detailed evaluation of a 16.2 ha (40-acre) parcel. The study dealt with the feasibility of implementation, residential servicing costs, and qualitative issues such as the nature and quality of the residential lots, streets and neighborhoods.

1.4 Report Structure

The sections of this report include:

- Section 2: a review of the literature and background
- Section 3: a description of the natural networking system, including technique, planning and infrastructure
- Section 4: a review of costs
- Section 5: a discussion of the suitability of natural networking, both from a market perspective and a regulatory perspective, and
- Section 6: conclusions and recommendations.

A bibliography is attached.

1.5 Previous Investigations and Present Situation

The Natural Network Subdivision was developed on a small scale in Cottonwood Park, Wyoming. However, the development was not followed through and due to modification of the

system did not verify the claims that savings in the range of 15-20% could be made with respect to reduction of service lines and roadways.

1.6 Literature Review, Design, Costing & Discussions

The design method involved applying the NNS planning technique to a typical parcel of land being considered for development in the Edmonton region. A parcel of land located in southeast Edmonton was identified for the application of this planning technique (Figure 1, Page 6). The overall scheme was prepared for a 64.7 ha (160-acre) parcel (Figure 2, Page 7) with detailed planning being undertaken for a 16.2 ha (40-acre) parcel (Figure 3, Page 8).

The following planning process was used:

- Research that included reviewing literature on the natural network approach and the theory behind it and interviewing individuals who are pursuing the natural network model. Extensive input was also obtained from Robert W. Corbett, noted for his work in this area.

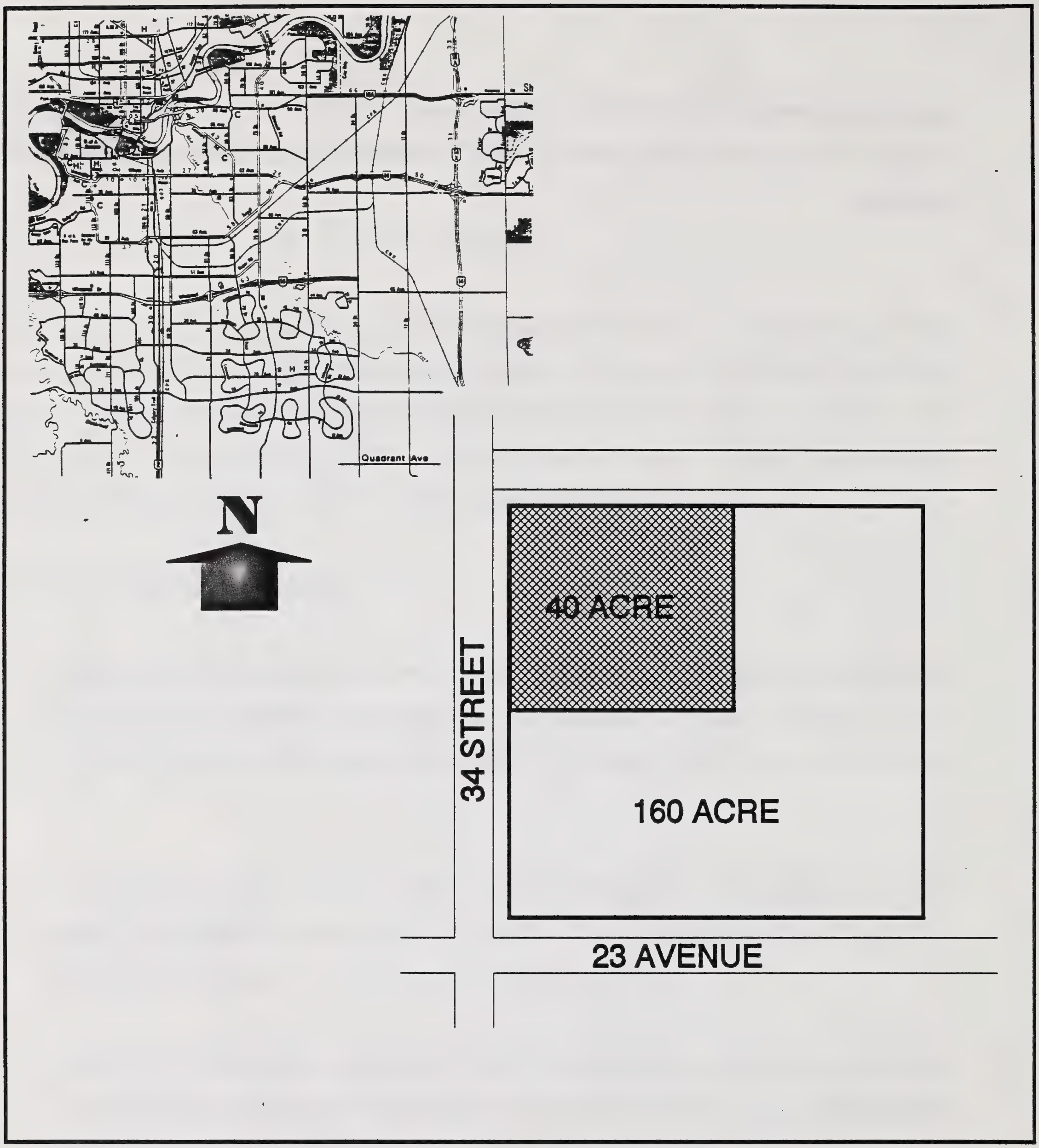
- A general area design plan was prepared for a 160-acre area and a detailed plan was created for a smaller 40-acre parcel. As required, some prototypical house plans were developed to illustrate how the unique lots could be utilized.

- A detailed cost analysis for each one of the NNS infrastructure components was made on a comparative basis against a conventional subdivision in the same area. A comparative analysis was also made of the various lot values in each layout.

- Meetings were held with representatives of the City of Edmonton and utility companies to obtain their views of the concept.

The findings of this report will provide the basis for future exploration of natural networking as

a planning approach in Alberta. As an alternate planning form it will broaden the base of the markets for subdivision development and will encourage other unique approaches to subdivision planning.



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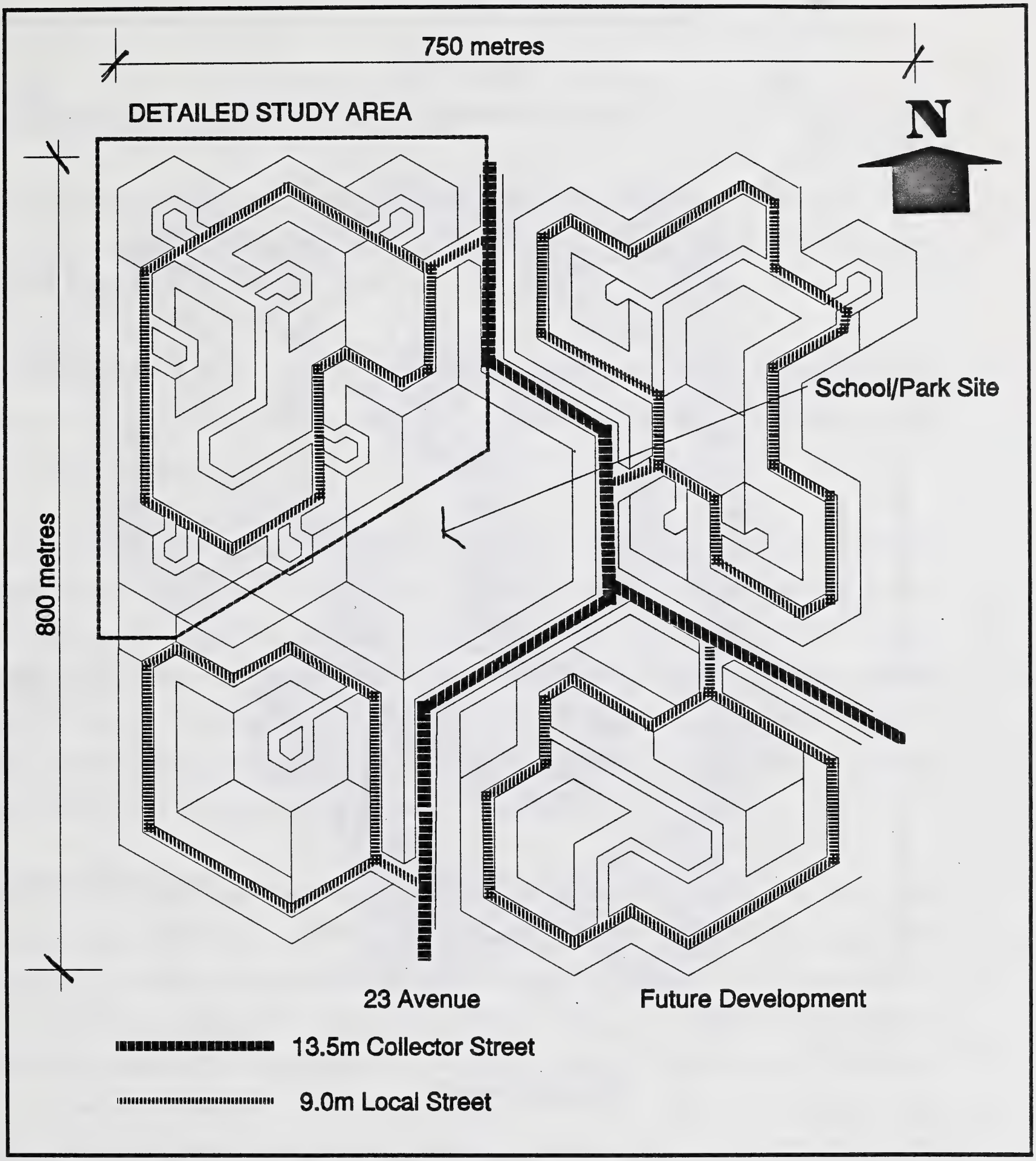
LOCATION MAP

NATURAL NETWORK SUBDIVISION
figure 1



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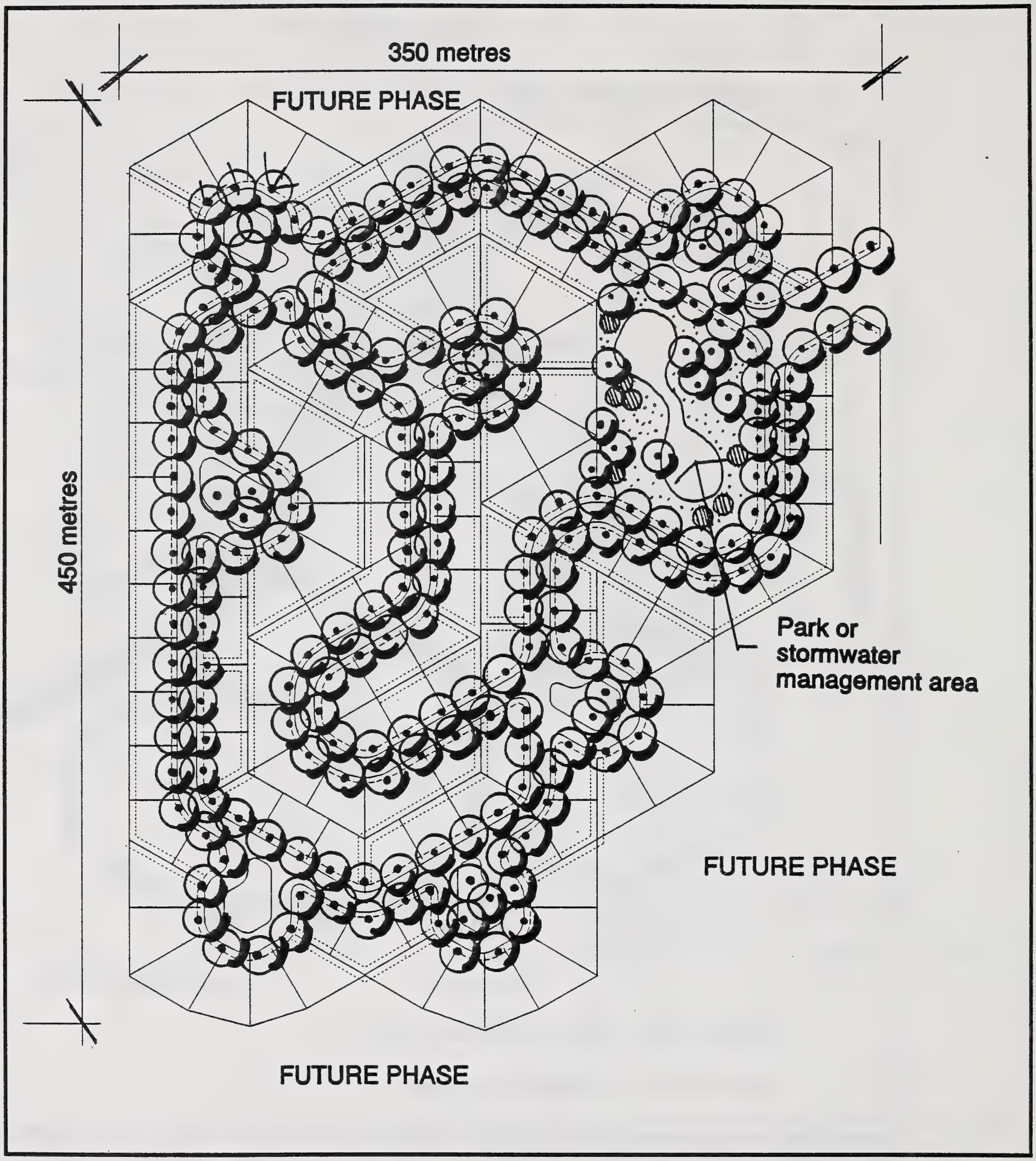
64.7ha. (160 Acre) PARCEL

NATURAL NETWORK SUBDIVISION

figure 2



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16.2ha (40 Acre) PARCEL

NATURAL NETWORK SUBDIVISION

figure 3

2.0 LITERATURE REVIEW AND BACKGROUND

Because the Natural Network Subdivision (NNS) represents an innovative planning approach, only a small amount of literature exists. However, there are publications and information available on the underlying theory of the NNS.

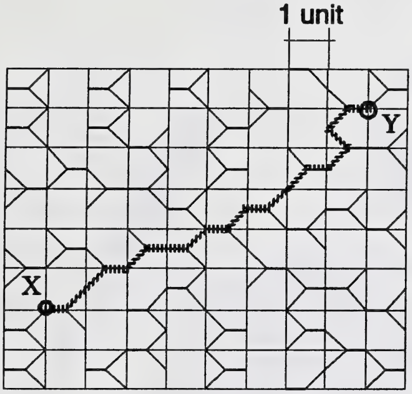
The initial interest in using a natural geometric shape in urban planning was triggered by the theories of Peter Pierce, author of Structure in Nature as a Strategy for Design and by Buckminster Fuller who is noted for his exploration of the geodesic dome.

Pierce postulates that man's successful fit into the built environment depends on the possibilities for change and adaptation within the context of resource conservation. In nature there are a variety of systems employing repetition in areas such as tree growth, corals or bee hives to produce unique structures from simple units. However, as shown in nature, repetition need not imply conformity or uniformity. When properly used, the principle of component standardization provides a system of great production and distribution efficiency. Following nature's predilection for efficiency, these systems usually conserve resources.

One of the most economical partitioning systems of a two dimensional plane is the polygon, from which the NNS has been derived. The polygon exhibits the following advantages when considered in a road planning application. The polygon pattern shortens the distance between two points when compared to a grid pattern (Figure 4, Page 11). Three-way connections, particularly when used as road intersections, reduce the amount of potential conflict compared to a four-way intersection. A tree-like pattern of branches forms the collective utility infrastructure, with small branches flowing into larger branches and branches into trunks. In a planning environment the branch anology translate into neighborhoods, cul-de-sacs, open space and circulation corridors.

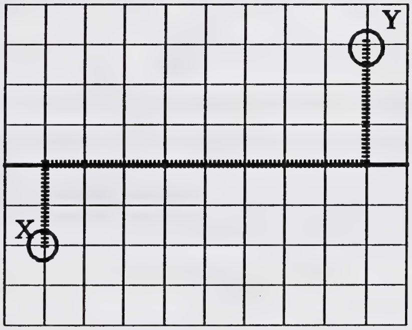
The polygon creates an extremely tight packing pattern to maximize utilization of land and NNS offers the freedom to accommodate many natural conditions such as creeks, top of banks and

environmentally sensitive areas. At grade, the system appears to be random and free flowing despite the strict order of its underlying geometric structure.



X-Y Connective distance = 11 units

The polygon modular grid offers a shorter connective distance between two points when compared to the regular grid pattern. A comparison of a variety of trips in both systems shows that the NNS layout reduces travel distances by an average of 15%



X-Y Connective distance = 13 units

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THEORY

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figure 4

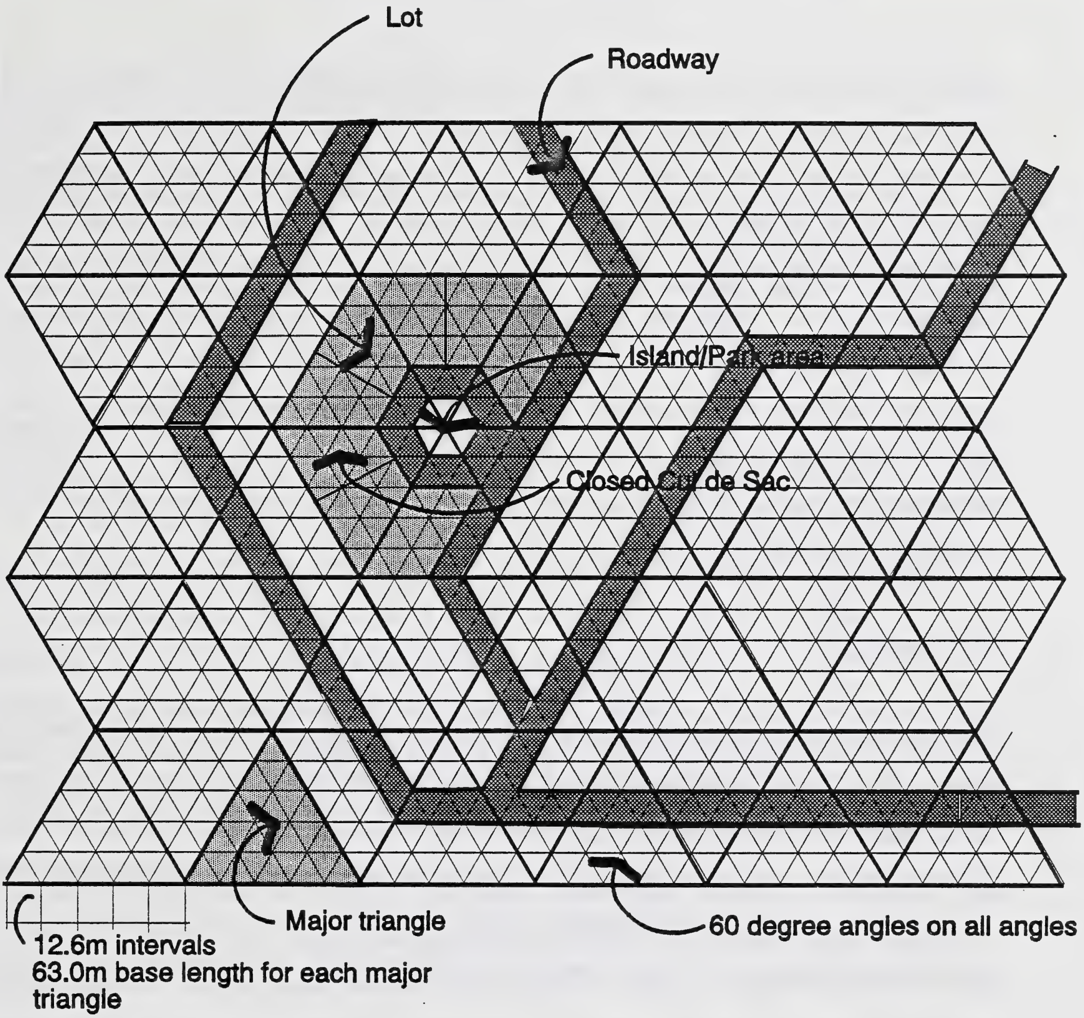
3.0 NATURAL NETWORK SYSTEM

3.1 Technique

NNS is a planning system based on a regular pattern of equilateral triangles (Figure 5, Page 13). The pattern is composed of major and minor triangles, with the major triangles subdivided into fifths by lines paralleling each edge to form 25 minor triangles.

Major triangles are the primary planning unit and combine to create pathways of development. The central row of minor triangles in the development pathway forms the road, and the two rows of triangles on either side form the lots. Pathways in major triangles can travel on any of the three axes of the system, and can bend and pack together in a variety of ways. One variation of the system creates focal, or cul-de-sac, lot groupings by utilizing three or more major triangles with a common apex. In these cases the roadways occur in the second tier of minor triangles, while the outer three rows join to form larger lots. The remaining apex triangle combines with adjacent ones to create a central cul-de-sac park or parking areas.

Although the system is especially adaptable to mixed residential development, this study addressed only single family lots in a variety of sizes, at a density of 4.3$\pm$ lots/acre in order to explore the concept's application in the predominant housing market currently being developed in Alberta. Various triangle sizes were used in determining the anticipated average lot size in the development of the NNS. As a result of this experimentation a major triangle module of 63 m (207.5 ft.) on a side and a minor triangle of 12.6 m (41.5 ft.) was selected. These dimensions were chosen as a result of being able to accommodate acceptable lot sizes and street widths for the regulatory authorities in Edmonton. It is possible to create smaller or larger lots by modifying the sizes of the triangles. Smaller triangles would be appropriate for components of multi or zero lot line housing and larger components are appropriate where land and servicing costs are not a major issue. The altitude of the minor triangle is approximately 10.97 m (36 ft.), which becomes the nominal widths of right-of-way for looped collector streets. The area of these minor triangles is approximately 69.2 sq.m. (745 sq.ft.). Lots are composed of from 6 to 10 or more triangles and vary from 415 sq.m. (4,468 sq. ft.) to 692. sq.m. (7,450sq. ft.) in area.



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GRID

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figure 5

Within this system there is a great deal of opportunity to develop various housing modes and circulation systems in response to the land available. Because of this flexibility, the NNS is adaptable to natural encroachments such as environmentally sensitive areas, major and minor surface drainage courses, top of banks, rivers, creeks, etc. This flexibility also allows for the provision of larger parcels of land which can be used for school, park, major commercial and multi-family sites. These sites generally require frontage on more than one road and the planning technique that will be described can easily accommodate this need. Further, the grid (triangle) dimensions can be increased or decreased to meet changing demands which may be based on economic or market requirements for various lot sizes. As a result of increasing or decreasing the size of the grid the roadway right-of-way will change and the lots will either increase or decrease in size correspondingly.

3.2 Planning

Data sources for planning are somewhat theoretical and for the most part reflect theories on how nature has evolved. Using these theories, however, it is possible to develop a physical form that can be applied to land areas and at the same time maintain a high quality of lot development. The configuration of the roads is unique as there are no perpendicular intersections and the whole design criteria is based on a three point intersection. At any one point it is possible to go in any one of three directions, and in all cases the angle between these three directions would be 120°.

The roadway system also is safer as there are no long, straight sections of road. The rate of travel decreases because a series of curves slows traffic. Because there are no quantitative changes in the physical condition of the roads, there is no deterioration in their suitability as service and emergency vehicle access routes. Because of the adapatability of the NNS system and the provision of pedestrian and bikeway linkages, subdivision school/park sites and smaller neighbourhood park sites can easily be connected without having major interfaces with the roadway circulation systems.

To commence design the grid is placed over the plan of the land parcel. Because of the ability

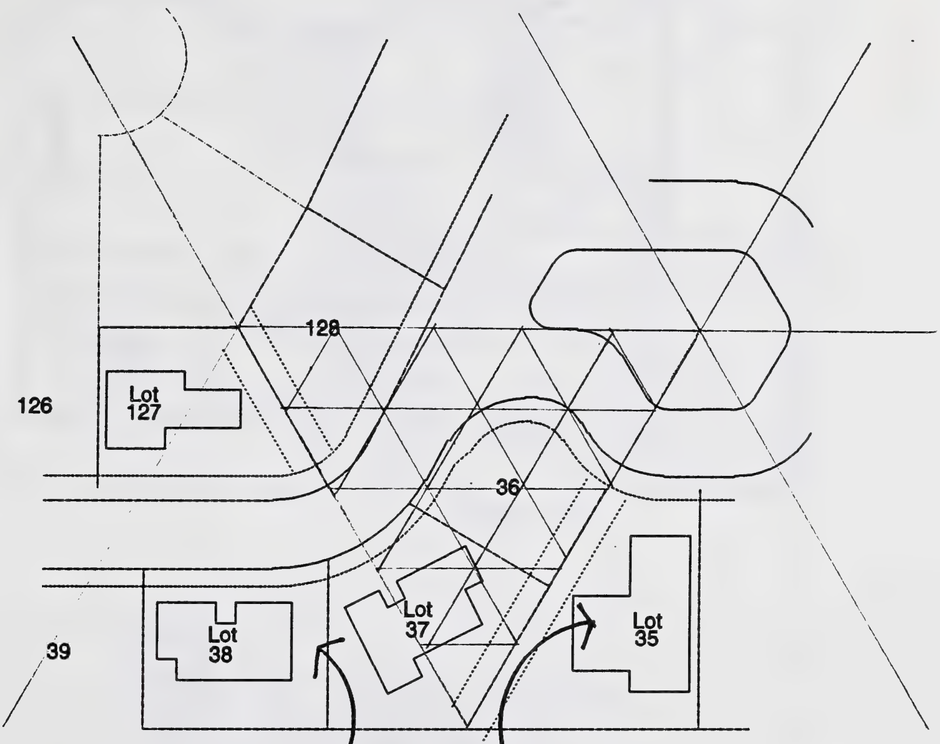
of the system to move in any one of three directions, it is easy to develop the transportation routes so they do not encroach onto the physical barriers of the site. It is possible to create unique lot groupings and at the same time create a natural form reflecting the physical ground conditions. Using a conventional approach, a tighter form must be applied to the land and the flexibility of direction is somewhat restricted. Using the conventional approach natural and physical occurrences may require engineering or reconstruction solutions.

This approach creates some lots that are not shaped in the conventional manner because they have more frontage than depth (See Figure 6, Page 17), and will require a unique housing form. This is not a disadvantage, rather it is an opportunity to offer consumers an exciting housing alternative which will provide them unique and revolutionary house plans. This housing form has been successfully used in the United States and examples of some projects have been published in the April 1990 Professional Building Magazine. Figures 7 & 8, pages 18 & 19 illustrate various home plans that have been used in these projects. For the more conservative market, conventional housing can be placed on a number of lots, particularly the cul-de-sacs, as shown on Figure 9, Page 20.

The quality of these lots in terms of sight lines, access and perceived streetscape is not compromised and provides a living environment that is at least equal, and generally superior, to current standards. In some cases there are improvements because of the number of cul-de-sacs created and the shortening of roadway links, which create the feeling of smaller neighborhood units. These arrangements are extremely successful because they develop a sense of place within the overall community. The cul-de-sacs are in demand by landowners who are prepared to pay a premium for lots in these configurations. These cul-de-sacs allow for the creation of major islands within the street which can be developed as mini-parks or off-street parking and because of their relationship to the roadways, can benefit the housing development.

In the view of a residential marketing consultant, this approach contributes to the quality of the lots. The detailed assessment of the individual lots is shown in Table 2, Page 34.

To facilitate planning, the triangular grid was placed on a computer assisted drafting (CADD) system and modified to the appropriate scale for the development of roadways and lots. As a result of the dimensioned sub-units that are used for the triangular grid, as were discussed on Page 12, the NNS results in a narrower road right-of-way, than is typical in Edmonton, and the placement of utility easements on lots; however, utilities easements do not restrict building setbacks. If the road right-of-way widths were increased this would result in recalculation of the triangular grid which would increase the size of the lots.



These lots lend themselves to innovative home designs.

Conventional lot and housing forms can be used in cul de sacs if required by the market

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LOT FORMS

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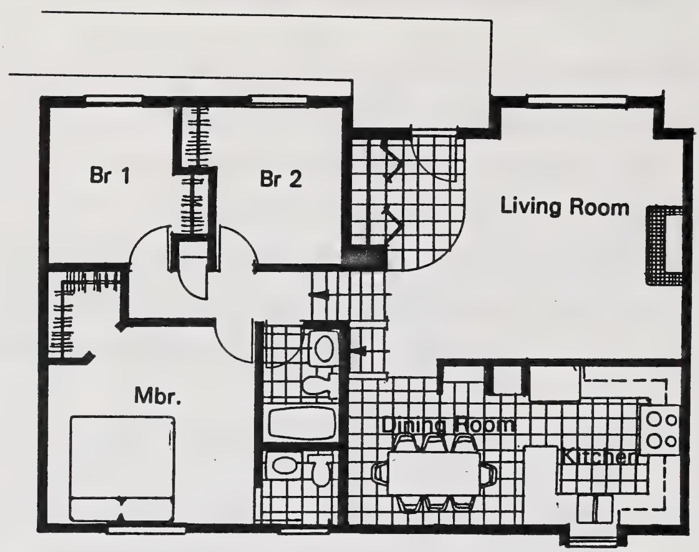
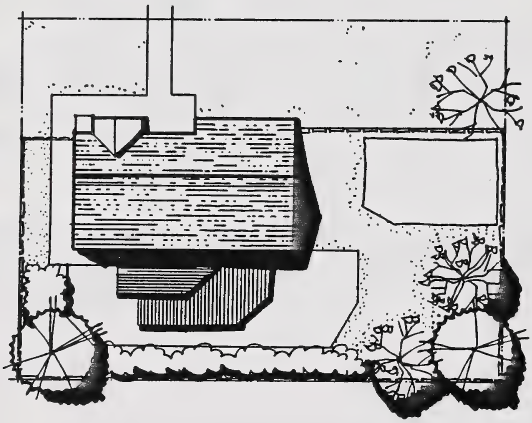
figure 6





Non cul de sacs lots are wider than deep and will require house designs that will accomodate this lot form. The lots and houses offer the same square footage as conventional lots, but a different approach to house design will be required.

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ALTERNATE HOUSING FORM

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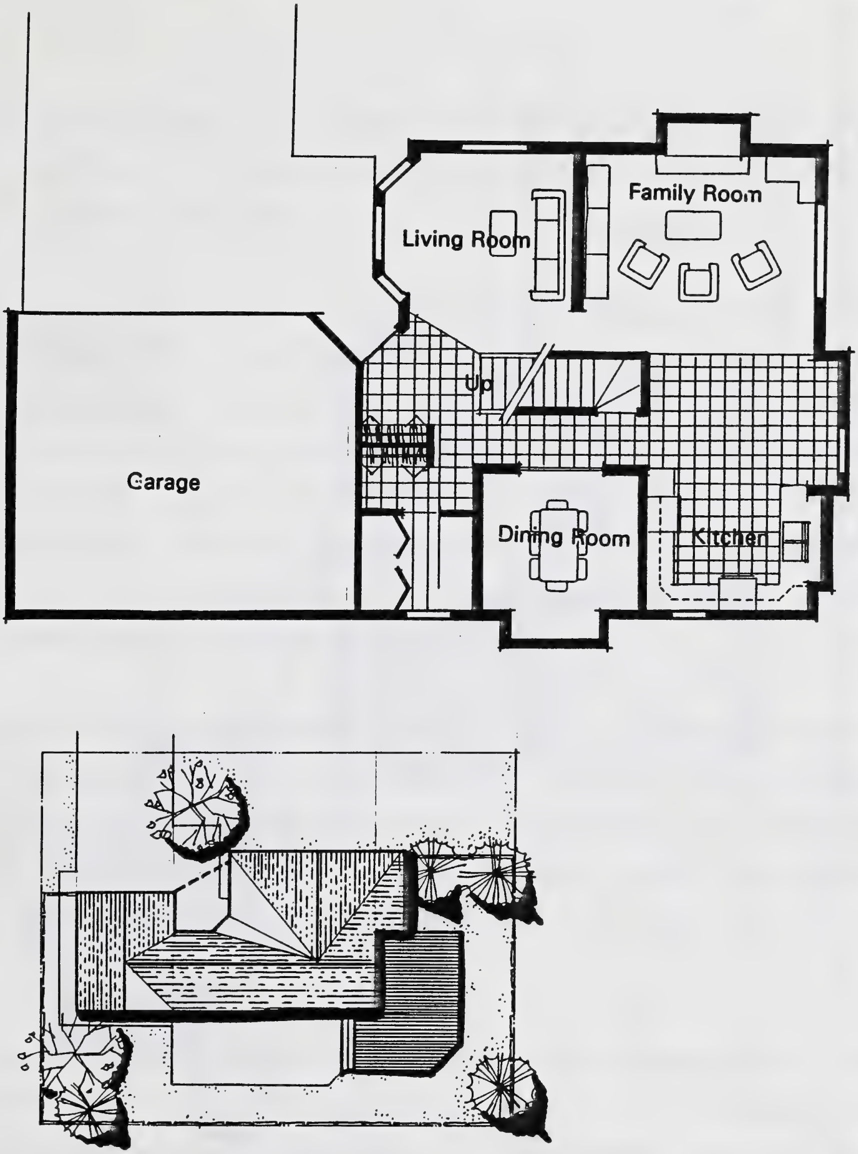
figure 7



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ALTERNATE HOUSING FORM

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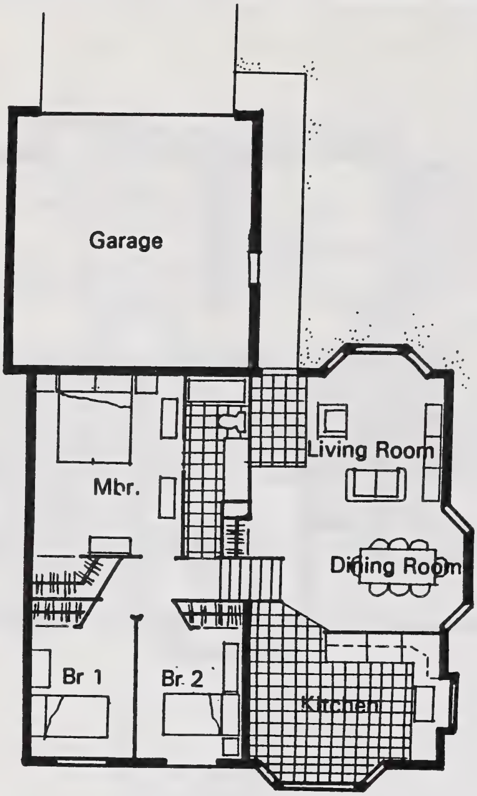
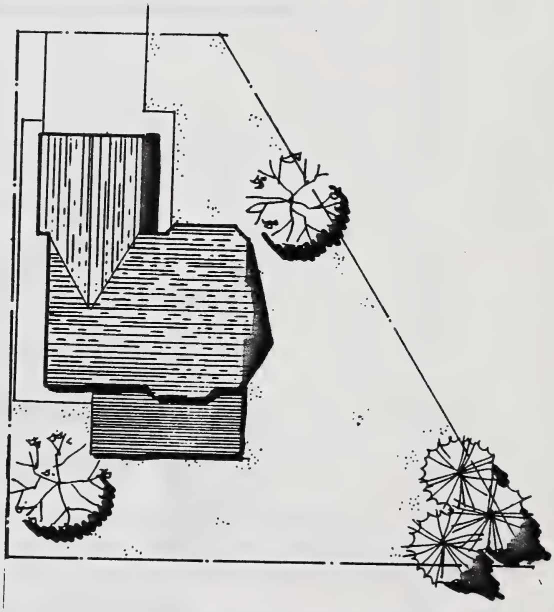
figure 8



Conventional house design can be used on the cul de sac lots and various lots throughout the system that can accomodate them.



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CONVENTIONAL HOUSING FORM

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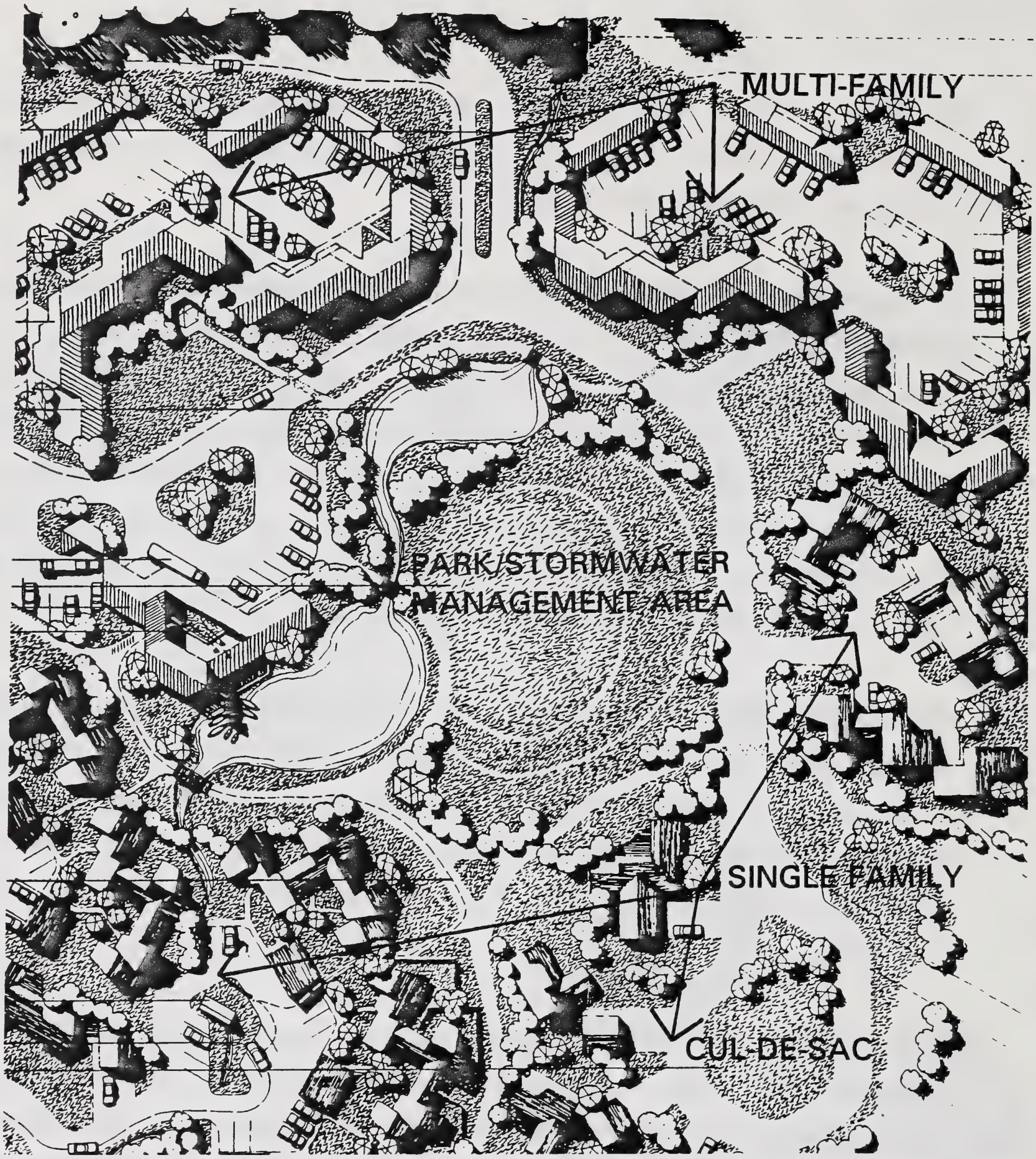
figure 9

The system is adaptable to all open-space requirements and provides an unique and acceptable physical form. As shown in the overall network, the cell structure is readily adaptable to ongoing growth into larger planning units.

The system also lends itself to multiple housing with potential unique applications to this approach (Figure 10, Page 22). In view of changing housing markets and the need for long-range planning in land assembly, this design flexibility is seen as an attractive feature of the NNS system. Multiple housing is particularly adaptable to the outside edges of a developed cell where the interface between NNS and conventional systems results in larger spaces that lend themselves to this form of development. Naturally, these larger spaces can also be used for large single family lots. However, if the NNS were to continue to grow, it need not result in larger lots until such time as it interfaces with a non-conforming land pattern.

The NNS system is very easy to manipulate and allows for unique design forms and circulation, once developers and planners have become familiarized with the approach. A further advantage is that the NNS is extremely compatible with computer assisted drafting; i.e., AutoCadd, Munmap, Microsurvey, etc. Various alternatives can be developed by computer and evaluated at that stage, to ensure that the resulting form would be suitable to the land on which it is to be developed.

Because of its departure from conventional planning techniques, there may be a tendency to try to manipulate NNS design to conform with more common practices. This is unnecessary, for during the course of this research, the participants were unable to identify or conceive of a planning situation which could not be resolved through the formalized application of the NNS system; however, with manipulation, there would be a reduction in potential cost savings as was the case in Cottonwood, Wyoming.



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COMPREHENSIVE HOUSING MIX

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figure 10

3.3 Infrastructure

One of the major benefits of this subdivision form is the reduction in lot servicing costs that arises from savings in both the utility and roadway components of the site development.

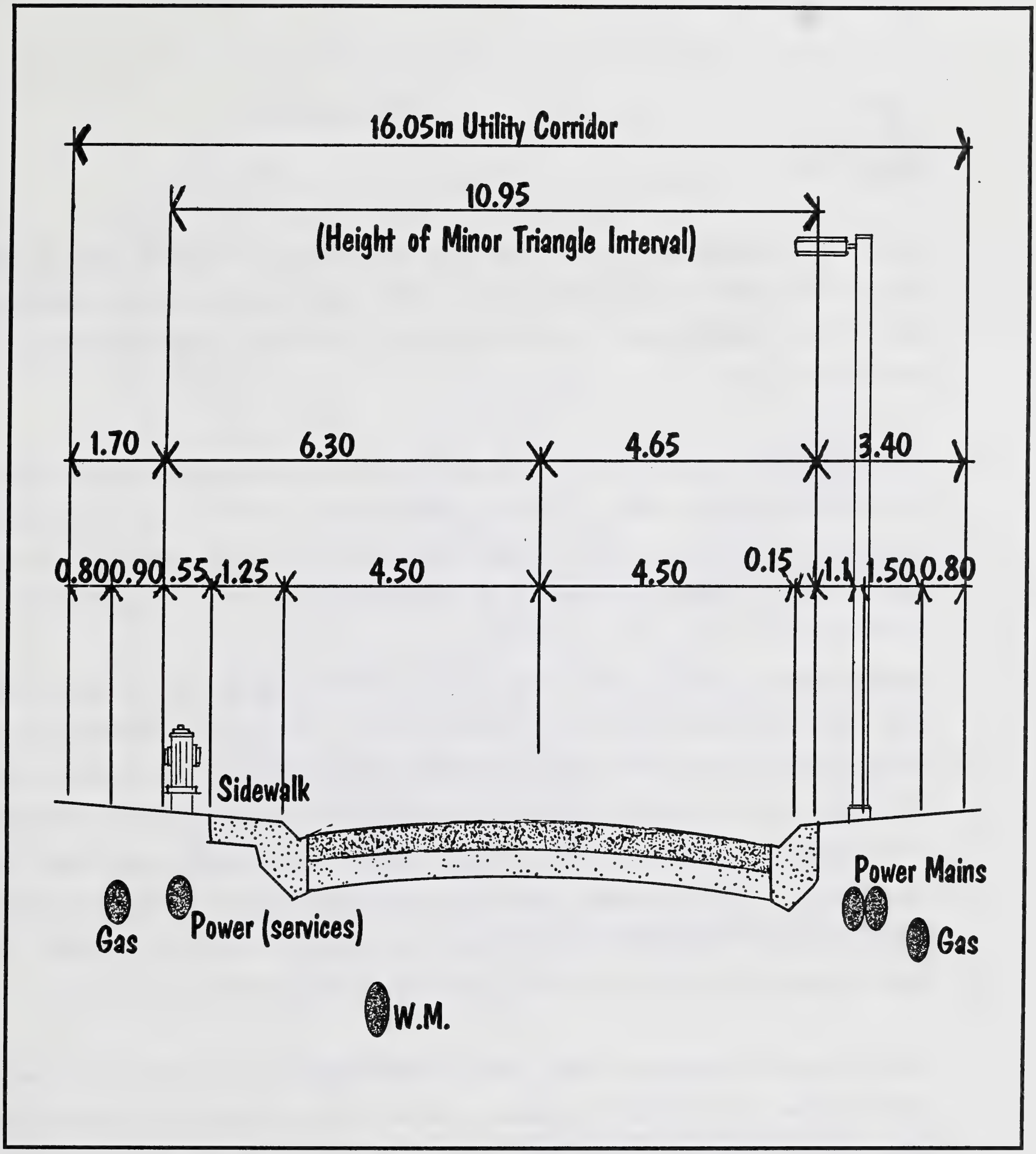
3.3.1 Roadways/Circulation

The NNS does not differ from conventional design in the way it would interact with the regional transportation systems. Major arterial and higher roadway classifications are typically developed on a grid system and the NNS conforms to prevailing road network patterns. The NNS road network would mesh with adjacent developed lands of varying uses and is identical to conventional layouts in its ability to connect to external road systems. The roadway classification proposed with the NNS is typical of local residential standards for 100 - 150 lot neighborhoods, with residential collector roadways connecting the neighborhood to adjacent arterial roadways.

The original development in Cottonwood Park, Wyoming, focused on multi-family housing with limited single-family housing. Because of this, the carriage-way widths of these roads were narrower than those in Edmonton and most parking was provided off street. This is not in line with the design norm in Edmonton; however, it was possible to adapt the NNS to City standards. A recommended carriage width of 9 m allows for two-way traffic with parking on both sides. The road right-of-way is 10.95 metres with easements on both sides for utilities. A typical section of this configuration is shown on Figure 11, Page 25. As shown, there is a sidewalk on one side of the street with utilities contained within easements on the lots. This has become a common practice in Edmonton, although not to the extent proposed in this study.

To facilitate emergency response vehicles, in particular fire trucks, secondary access to the neighborhoods would be provided from adjacent roadways by means of walkways. These walkways would be located, constructed and utilized in the same fashion as they are used today in conventionally planned subdivisions. Although shown only roughly in the detailed subdivision plan, the walkways are an integral part of the overall planning form of the NNS and would

accommodate both pedestrian and emergency vehicle access. The walkways would also facilitate looping of utilities between neighborhoods. Where a walkway is used for utilities and access, it would be designated as a public utility lot as done in conventional planning to ensure that the parcel would not be leased to adjacent lot owners.



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RIGHT OF WAY X-SECTION

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figure 11

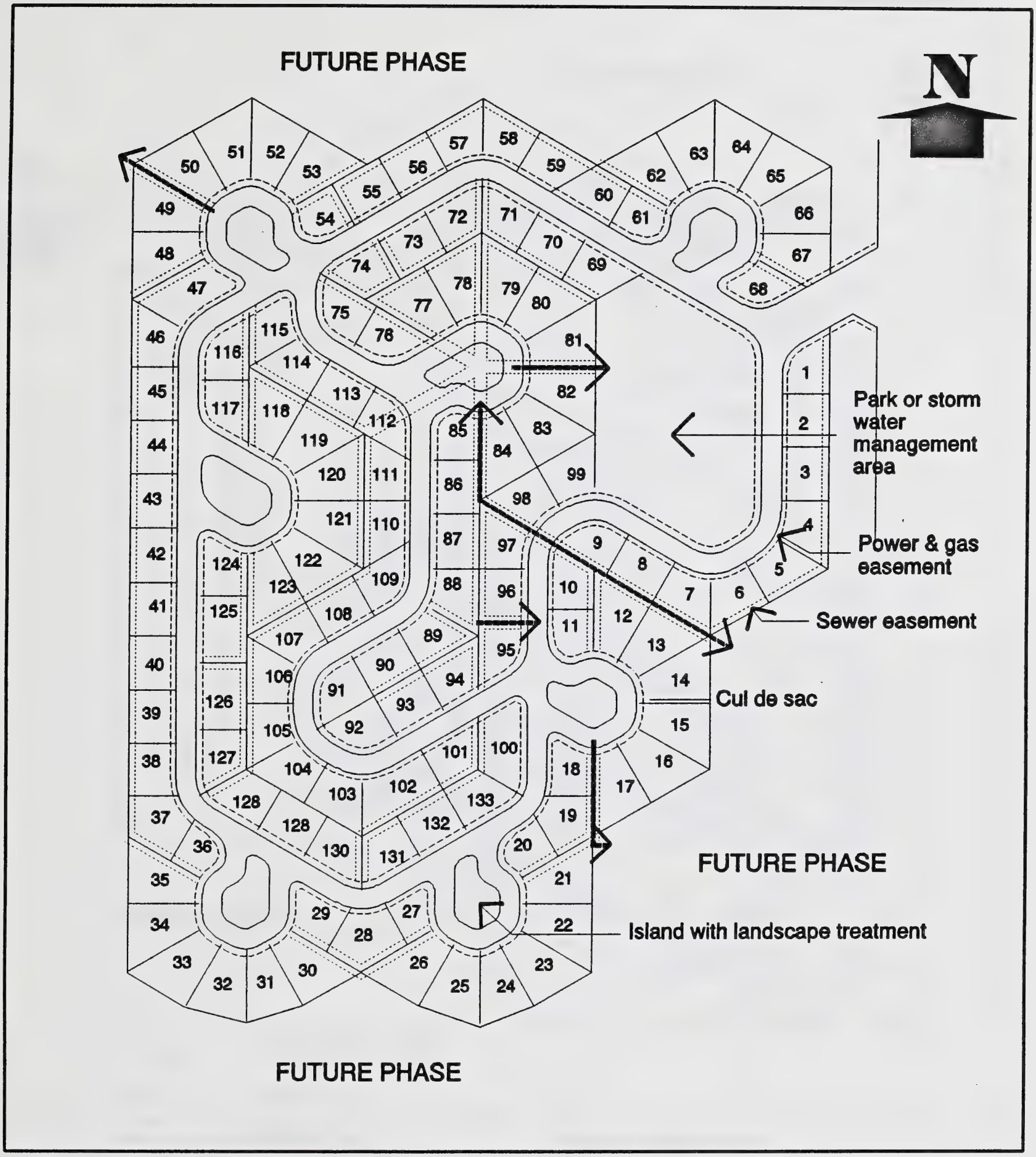
3.3.2 Utilities

Utilities can be categorized as either distributive or collective. Distributive ones are those services which require a pressure or force, i.e., water, power, telephone, which consequently must be looped and continuous. Collective utilities, such as sewers, are not looped and can be collected at one point.

Because distributive systems must be looped, it is convenient to have them contained within the road right-of-ways as the roads are also looped and connecting. The sewer system can be located in easements at the back of the lots. The proposed roadways, easements and lots are shown on Figure 12, Page 27 and the utility layouts are shown on Figures 13 & 14, Pages 28 & 29.

Installing sewers at the back of lots will require service connection points from the back of house to the sewer line. Storm sewers will still function as in a conventional subdivision; however, the alignment of the lines will be at the back of lots. Drainage collection points on the streets are accommodated as in conventional subdivision development. Lot drainage would be the same as in a conventional subdivision with either back to front or rear yard drainage which is no different than present development. Easements and utility right-of-ways at the back of lot can be found in current subdivisions as gas and power easements are often located at the back. The major difference is that the sewers would be installed deeper than gas or power lines.

The utility layout, roads and lot shapes are some of the more unique elements of the Natural Network System. In particular the collective systems (sewers) strongly reflect the tree branch analogy which is the basis for the NNS concept. As well the roads with the three point intersections strongly reflect the tree analogy that has been described. The principles that have been identified can provide a potential savings in the servicing of the land through overall reduction in service line lengths as a result of the natural form that forms the basis for the subdivision design.



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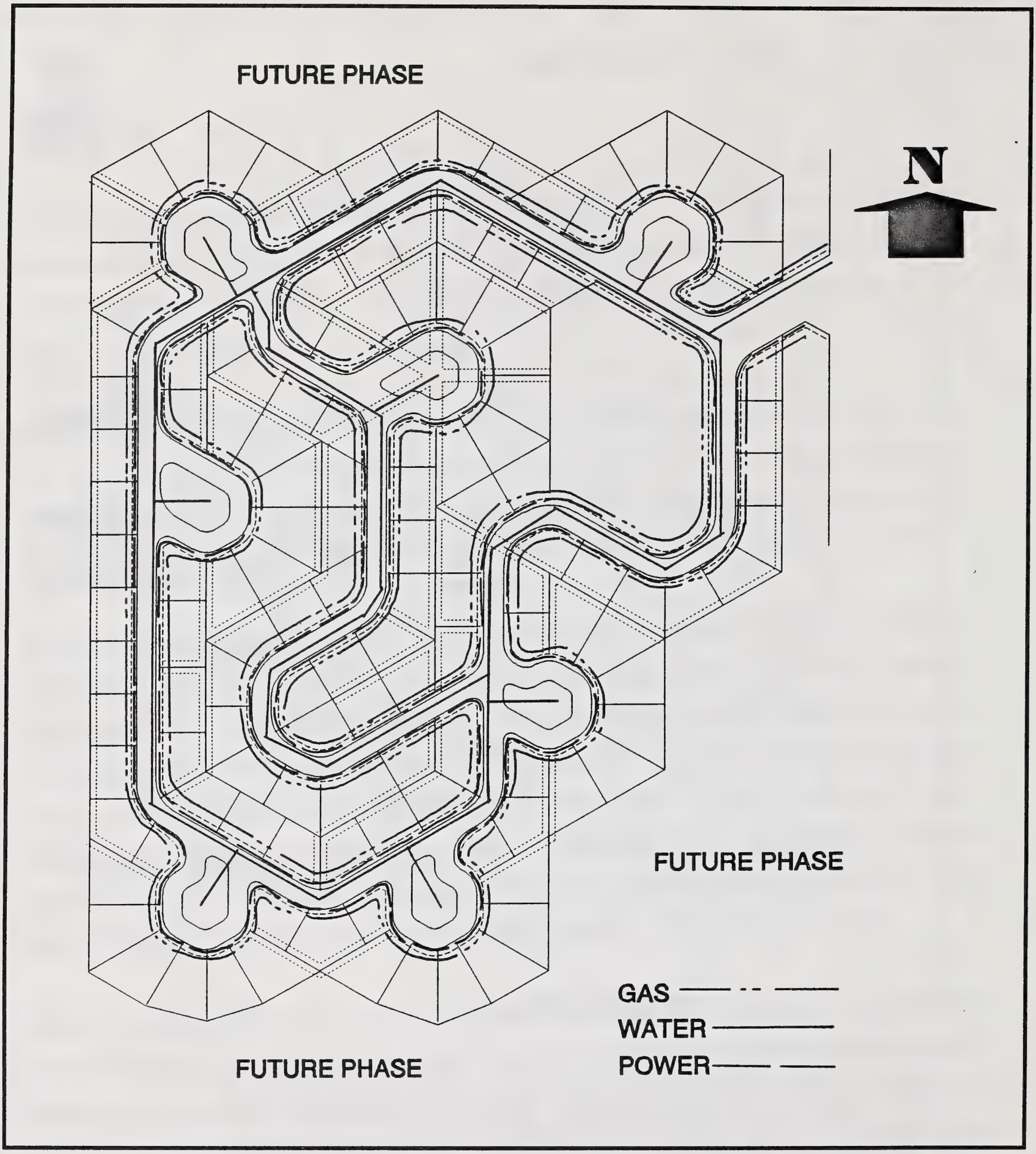
ROADS, LOTS, & EASEMENTS

NATURAL NETWORK SUBDIVISION

figure 12



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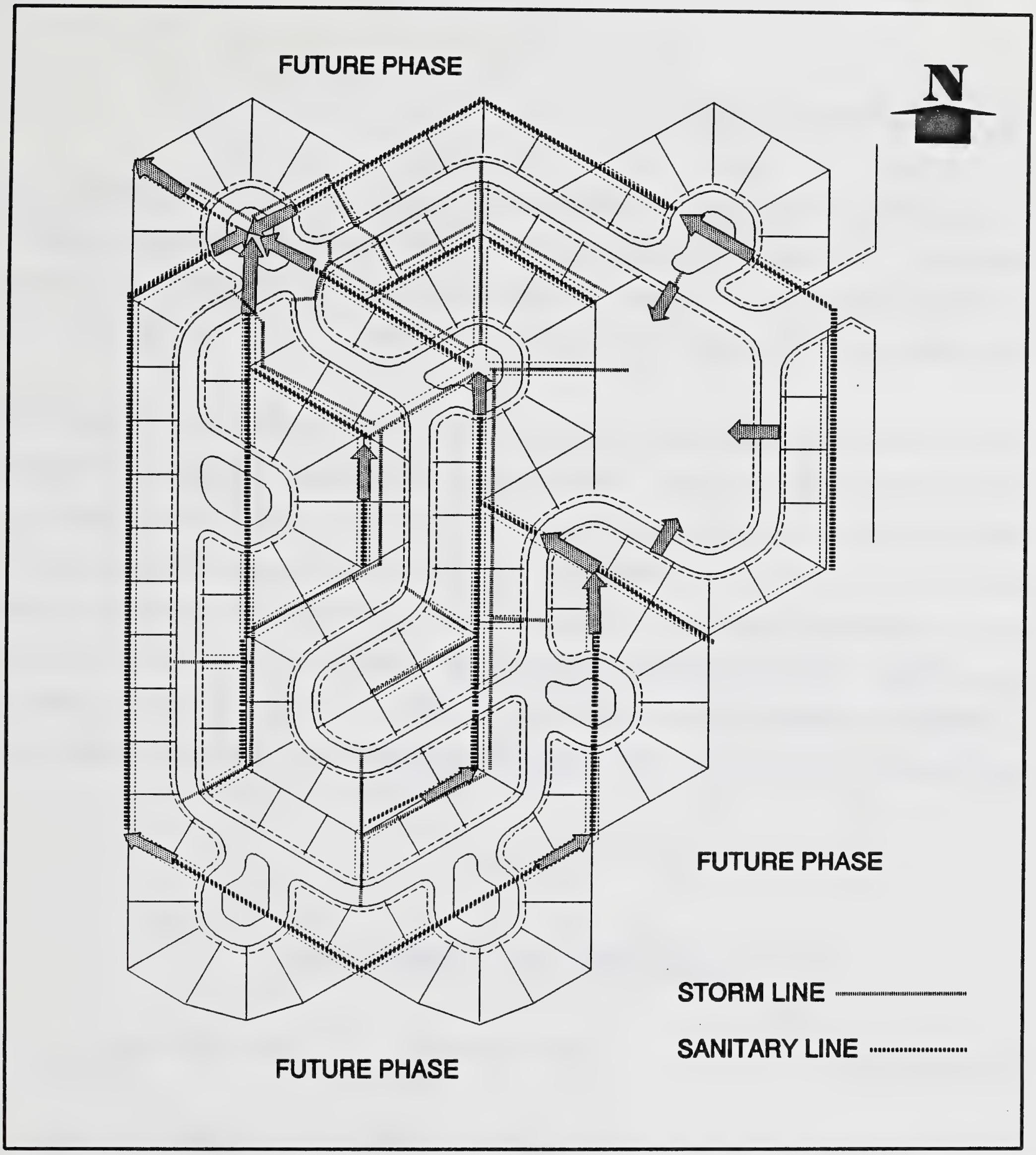
GAS, WATER, & POWER

NATURAL NETWORK SUBDIVISION

figure 13



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SEWERS

NATURAL NETWORK SUBDIVISION

figure 14

4.0 DEVELOPMENT COSTS

A comparative cost analysis of a conventional subdivision and the NNS subdivision was undertaken. The comparison applied standard unit construction costs to measured quantities of the various services in each proposal. Because the schemes were on adjacent tracts of land, construction priorities and unit costs were taken as identical.

The conventional subdivision was estimated to cost \$23,700 per lot, while the NNS cost \$20,600 per lot; a 13% reduction in costs. This includes all site preparation, infrastructure work and related engineering/development costs, but does not include the cost of the land or carrying cost which should be considered equal for the purposes of this study. Because of the configuration of the comparative (conventional) subdivision the per lot cost of the sanitary sewer was higher for the NNS, however, on a larger scale the NNS would provide a cost per lot less than a conventional subdivision for the sanitary sewer system. In both instances the density is approximately 4.3 lots per acre. The detailed cost analysis of each subdivision is noted below.

TABLE 1

COMPARISON OF ALTERNATIVES

DESCRIPTION	CONVENTIONAL		NNS NETWORK	
		PER LOT		PER LOT
1. Site Preparation	\$ 151,000	\$ 1,094	\$ 90,000	\$ 677
2. Sanitary Sewers	\$ 218,000	\$ 1,580	\$ 233,000	\$ 1,752
3. Storm Sewers	\$ 285,000	\$ 2,065	\$ 189,000	\$ 1,421
4. Watermains	\$ 281,000	\$ 2,036	\$ 216,000	\$ 1,624
5. Stormwater Pond	\$ 650,000	\$ 4,710	\$ 600,000	\$ 4,511
6. Road Works	\$ 784,000	\$ 5,681	\$ 633,000	\$ 4,759
7. Service Connections	\$ 127,000	\$ 920	\$ 115,000	\$ 865
8. Power & Street Lighting	\$ 385,000	\$ 2,790	\$ 306,000	\$ 2,300
9. Engineering	\$ 385,000	\$ 2,790	\$ 357,000	\$ 2,684
TOTAL	\$3,266,000	\$23,666	\$2,739,000	\$20,593

	Conventional	NNS	Savings
Cost Per Lot	$23,666	$20,593	$ 3,073
Total Area (Acres)	31.6	30.5	
Number of Lots	138	133	
Number of Lots Per Acre	4.37	4.36	

5.0 SUITABILITY

5.1 Market

With respect to the quality of the lots, values based on perceived qualities (Table 2, Page 34) were assigned by a marketing consultant, with experience in subdivision sales, to each one of the lots. This value was based on the ability to sell and the opportunity to develop a standard house. In assigning values, many factors which affect the overall quality of the lot for residential use have been considered. These include the location, the exposure and the quality of view provided, proximity to open spaces and streetscape appeal. Cul-de-sac locations, for example, received a higher value than those on more conventional sites. The potential of the lot to provide for outdoor amenities such as decks, patios and attractive landscaping was also evaluated. Negative factors include exposed corner lots and poor views.

Negative values were not assigned to broader but shallow lots, since floor plans are readily available for such lots. These floor plans allow for all the amenities that can be included on more conventionally-shaped lots. Indeed, this lot shape may prove to be a positive aspect, as these lots can accommodate the broader, more impressive frontage which many markets have discovered to be highly desirable.

The rating system is as follows:

CATEGORIES:

A + 20 *(50%) (Best)
A + 15 (38%)
A + 10 (25%)
A + 5 (13%)
A (Base Lot)
A - 3 (-8%)
A - 5 (-13%) (Worst)

ADD:
10 for dry pond
5 for good exposure
5 for food location

DEDUCT:
3 for exposed corner lot
5 for location, i.e., poor view, on long street, or unfavourable exposure

- A assumes average lot cost of $40,000 in 1991 dollars
- assumes compatible adjacent land use
- % relative comparative increase/decrease

* Figures are in $1,000's

Current demand favors larger lots with more open space and the NNS compares very favorably in this regard. Generally, the lots in the NNS have smaller variations in size and are bigger than those in conventional subdivisions. However, if for any reason the lot sizes must be altered, the NNS can be readily adjusted. This can be done by modifying the size of the triangular units, thus reducing or enlarging the resultant lot to meet market demands. As shown in the density calculation, the NNS, based on the triangular dimensions described on Page 12, yields the same number of lots per acre as a prevailing conventional subdivision.

An analysis of the lot price variations in Table 2, using the rating system described in this section, shows that the 133 lots have enjoyed a total increase in value of some $762,000. This represents an average per lot increase of $5,730 or approximately 15% on the base price of $40,000.

TABLE 2
NATURAL NETWORK SUBDIVISION

Lot	Size (sq.m)	Rating *	Lot	Size (sq.m.)	Rank	Lot	Size (sq.m)	Rating
1	521	A-5	49	727	A+15	97	554	A+5
2	554	A-3	50	727	A+15	98	554	A+10
3	554	A-3	51	727	A+15	99	554	A+15
4	554	A-3	52	727	A+15	100	840	A+10
5	554	A	53	727	A+10	101	554	A
6	554	A	54	429	A	102	864	A+10
7	554	A	55	554	A+5	103	554	A+5
8	554	A	56	554	A+5	104	554	A+5
9	521	A-3	57	554	A+5	105	554	A+5
10	554	A	58	554	A+5	106	554	A+5
11	429	A	59	554	A+5	107	554	A+5
12	727	A+15	60	554	A	108	554	A+5
13	727	A+15	61	429	A+15	109	521	A
14	727	A+10	62	727	A+15	110	554	A+10
15	727	A+10	63	727	A+15	111	554	A+10
16	727	A+10	64	727	A+15	112	521	A
17	727	A+10	65	727	A+15	113	554	A
18	554	A-3	66	727	A+10	114	554	A+5
19	673	A	67	667	A+10	115	523	A
20	429	A-3	68	469	A	116	521	A-3
21	727	A+10	69	554	A+10	117	521	A+5
22	727	A+10	70	554	A	118	727	A+15
23	727	A+10	71	554	A	119	727	A+15
24	727	A+10	72	554	A	120	727	A+15
25	727	A+10	73	554	A	121	727	A+15
26	727	A+10	74	554	A	122	727	A+10
27	376	A	75	521	A-3	123	727	A+10
28	673	A	76	521	A	124	521	A
29	727	A-3	77	727	A+15	125	693	A+5
30	727	A+5	78	727	A+15	126	693	A+5
31	727	A+10	79	727	A+15	127	554	A
32	727	A+10	80	727	A+15	128	554	A+5
33	727	A+10	81	727	A+20	129	554	A+5
34	727	A+15	82	727	A+20	130	554	A+5
35	727	A+15	83	727	A+15	131	554	A+5
36	345	A-3	84	727	A+10	132	554	A+5
37	673	A+5	85	429	A-3	133	554	A+5
38	554	A+5	86	554	A			
39	554	A+5	87	554	A			
40	554	A+5	88	554	A			
41	554	A+5	89	554	A			
42	554	A+5	90	554	A			
43	554	A+5	91	521	A			
44	554	A+5	92	521	A			
45	554	A+5	93	554	A+5			
46	554	A+5	94	554	A+5			
47	760	A+10	95	521	A			
48	727	A+15	96	554	A+5			

* Figures are in $1,000's

5.2 Regulatory Considerations

The study also reviewed the legislative implications of the proposals that have been made. Various meetings were held with the City of Edmonton and utility companies to discuss the concept. In a broad planning sense the concept has been accepted; however, there are some concerns with respect to specific issues regarding the utilities. These will be addressed in this section along with comments on the acceptability of the NNS from a regulatory perspective.

5.2.1 General Planning

The NNS concept has been accepted by the City of Edmonton as a good land use method and a reasonable alternative to conventional subdivision planning. Because of its ability to accommodate various restrictions such as drainage courses, adjacent existing land uses and still comply with the overall requirements for vehicle circulation, it was proposed that this subdivision should be considered for development in the City of Edmonton. Specific issues would have to be addressed such as lot sizes and set backs; however, where a variation to present zoning standards exist, it was suggested that the NNS be developed under a direct control zoning (DC) regulation whereby the regulatory authorities would have the option to approve conditions that are contrary to present zoning standards. The City of Edmonton is prepared to consider NNS for construction in the city subject to the resolution of technical matters.

5.2.2 Utilities

A number of minor issues were identified with respect to set backs and distances between utilities and these have been accommodated and are represented on the typical cross-section (Figure 11, Page 25). However, there was a major concern with respect to the placement of utilities at the back of lots. The concern focused on the potential response of the homeowners to future repairs in their yards, particularly if a major repair or upgrade were required. The utility companies were concerned about entering onto mature landscaped yards to undertake repairs. If replacements have to be undertaken, an area would be required for full excavation, materials

storage and side slopes. This could encompass a major portion of a lot and may be unacceptable to the lot owner. The concern is that while the initial purchaser of the lot would be aware of the easements at the back of the lot, any subsequent buyers may not be aware of this situation and in the event access was required they could object to the damage. The city would not be responsible for repairing the owners improvements and they felt this situation would create a conflict.

The City of Edmonton suggested that if utilities were to be installed, they would not be identified as easements but would be public utility lots under the ownership of the city. Although utility lots could be leased by the Owners it could still create difficulty for utility companies to gain access to these areas.

Another issue that was identified, however minor, was the responsibility for ground settlement on the utilities. Utility companies are not prepared to go into yards to repair settlement and undoubtedly owners would look to the regulatory authority for correction of any settlement that would occur.

The overall concept as a land use and the ability to implement the Natural Network Subdivision from a land planning point of view can be coordinated with the City of Edmonton. However, during the review process and detailed design of the utilities, the issues that have been identified would be brought forward and resolved prior to obtaining subdivision approval. As noted in the study, the subdivision requires the alignment of the sewer utilities along the back of lots to achieve the maximum infrastructure cost savings that have been identified. If it is not possible to locate utilities in the proposed easements, the NNS would still be desirable in terms of the improved residential environment, increased property values and significant, although reduced, savings in servicing costs.

The key finding of this study, however, is that the overall NNS planning concept and land use can be considered for development in the City of Edmonton.

6.0 CONCLUSIONS & RECOMMENDATIONS

The initial belief that the servicing and infrastructure costs of residential subdivisions can be reduced by using the NNS technique has been confirmed by this study. The NNS is workable and does create new opportunities for subdivisions. These forms are unique and not only maintain a quality environment, but in many cases improve upon existing standards. The road network, for example, can provide safer thoroughfares by reducing the length and number of straight road runs.

Although the efficiency of subdivision servicing under NNS approach was proven, other questions arose that warrant further detailed study before validating the suitability of this approach in the broad Alberta market.

Elements that will require further study are;

1. Islands within the cul-de-sacs: Because of restricted operating budgets, municipalities are reducing maintenance funds. This would have to be reviewed in detail with respect to the design elements that would be incorporated into the islands. These islands could become high maintenance areas that would not be acceptable to municipalities. There are alternatives to these such as community responsibility for maintenance or a hard landscape approach, where hard surface materials are used instead of green landscaping, but this would increase the initial capital cost. There is also the possibility of using these islands for off street parking in order to reduce the road right-of-ways and eliminate onstreet parking.

2. Because of its innovative and unusual layout, there are unique opportunities to exploit the edge conditions where NNS cells meet conventionally planned areas. It initially appears that the resulting lots might lend themselves to large custom homes, or with equal ease they could be developed as multi-family sites. It would be appropriate to undertake a detailed study of a 64.7 ha (160 acre) parcel of land and identify how these

transitions can be made so as not to limit the development of adjacent lands while maximizing the overall potential of the NNS areas to accommodate a wide range of economic and social markets thus resulting in a diverse community.

3. Regulatory authorities: Some objections to the NNS were identified which would require modifications to the present practices for utility alignments. The major issue will be the negotiation of the utility locations and access with the approving authorities. However, these are only local requirements and do not contravene provincial planning standards. While the NNS land planning only partially complies with current zoning standards it can be accommodated by changing the zoning to direct control (DC) which would enable local authorities to approve NNS subdivisions.

The study does identify the NNS as a viable subdivision form that presents exciting opportunities for development. The study should generate interest within the development industry and municipal authorities. Because of the size of the detailed area that was undertaken, additional studies should be considered for indepth planning on a larger scale. This would confirm the feasibility and attractiveness of this design application on a community level.

The NNS provides exciting opportunities for alternative forms of residential land development. It also provides a comparable or improved environment and savings in development cost. The approach is unique and will provide the opportunity for new land developments which will provide another choice to developers and home purchasers. This is seen as a positive planning approach as it will provide new opportunities that are acceptable and compatible with current development standards.

As a result of the research and findings of the report it is hoped that developers will be encouraged to consider the natural network subdivision for future development. It does offer the opportunity for an alternate subdivision approach and at the same time provides cost savings and improves the quality of the living environment.

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